BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: The Tektite Project Behavior Program. Case 710.

DATE: April 11, 1968

FROM: N. Zill

MEMORANDUM FOR FILE

The Tektite Project is an undersea habitat concept originated by the General Electric Company and planned as a joint program involving the Department of the Interior, the Navy and NASA. It represents the first operational outcome of the efforts of the NASA-Navy Undersea Habitat Working Group and related NASA study contracts.

Although NASA has not at present committed funds to the Tektite Project, the Navy, Interior, and G. E. have, and active planning and construction of the habitat is proceeding. Therefore, psychologists in the Working Group decided to formulate a Behavior Program for Tektite which would incorporate the interests of all the above organizations. The undersigned was asked to compile and edit the contributions of the various group members.

The result, The Tektite Behavior Program: A Summary of Measurement Requirements, is attached.

A preliminary version of this document was considered by the contributors during a meeting at Bellcomm on March 22, 1968. Revisions suggested at and subsequent to that meeting, have been incorporated into the present document.

This summary of measurement requirements is submitted as an aid in evaluating the fruitfulness of NASA participating in Tektite, as a planning guide in the organization and execution of the final measurement program, and as an expression of the philosophy which has prevailed in the Working Group: that of obtaining maximum behavioral data from real-world operations with minimum interference with those operations.

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1011-NZ-cb N. Zill

Attachment
The Tektite Behavior Program: A Summary of Measurement Requirements

# THE TEKTITE PROJECT BEHAVIOR PROGRAM

## A Summary of Measurement Requirements


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# SUMMARY DESCRIPTION OF TEKTITE PROJECT

The Tektite Project is an undersea research station planned as a joint program involving the Department of the Interior, the Navy, NASA, and the General Electric Company. The principal features of this station are presented in summary form below.

| | |
|---|---|
| Location: | Lameshur Bay, St. John's, Virgin Islands. |
| Mission Concept: | Fixed undersea habitat with lines to shore for power, etc. "Saturated" research station with extensive EVA diving for marine biology and other research. |
| Atmosphere: | Hyperbaric (2 1/2 atmospheres absolute) $O_2$-$N_2$ mixture. |
| Habitat: | Double steel cylinders, 18' high, 12 1/2' dia. 2 levels in each, connected by crossover tunnel, mounted on a structural steel base. (Further details of the habitat layout and activities in each area are available in the Appendix to this document.) |
| Operating Depth: | 50 feet. |
| Duration: | 8 weeks. |
| Planned Starting Date: | Second half 1968 or early 1969. |
| Crew Size: | 4. |
| Crew Composition: | Scientist-divers from Dept. of Interior. |

## IMPORTANCE OF TEKTITE PROJECT

### I. Contribution to National Goal of Man's Extension into the Sea

The Tektite Project will be a demonstration that shallow water saturation diving can be carried out on a long-term basis with an oxygen-nitrogen breathing mixture. If successful, this will be a major step in opening large areas of the sea floor for research, exploitation, and habitation.

All previous extended saturation habitats have utilized a helium-containing breathing mixture. An oxygen-nitrogen atmosphere has the advantages of:

a) being much less expensive to support than a helium-containing atmosphere, and

b) having none of the voice communication or heat transfer problems that a helium-containing mixture causes.

However, a hyperbaric oxygen-nitrogen atmosphere poses the dual physiological problems, which increase with increasing depth, of:

a) nitrogen narcosis, and

b) increased pulmonary airway resistance due to the density of the breathing mixture.

All experimental evidence indicates that the Tektite 2 1/2 atmosphere pressure level is well below the threshold pressure region at which these effects become serious. However, Tektite will serve as operational validation of the viability of this atmosphere-depth combination on a long-term basis. Furthermore, the project will provide needed experience with the complexities of supporting a shallow-water saturation habitat.

## II. Significant Marine Research

The primary mission of the Tektite station will be the collection of marine biological, geological, and oceanographic data. Areas in which data will be gathered include:

1. Underwater behavior studies in feeding and schooling of local fauna (Bureau of Sports Fisheries).

2. Investigations of spiny lobsters and marine flora (Bureau of Commercial Fisheries).

3. Studies of aqua culture and the effects of pollution (Bureau of Commercial Fisheries).

4. Enrichment studies of natural coral reefs and the effectiveness of artificial reefs.

5. Classical geological survey of habitat area.

6. Environmental sensing by means of thermographs, current meters, dissolved oxygen recorders, etc.

In addition, the project will provide information on the more global questions of:

1. Does a fixed, long-term habitat provide enough of a data payoff to justify the establishment of similar research stations (as opposed to mobile undersea laboratories) in the future?

2. What are the best ways to organize and support such human scientific activity in an exotic, constrained environment?

III. Intensive Behavioral Study of a Natural Operation in an Exotic Environment

The principal features of the Tektite environment for behavioral research purposes are that:

a) it involves isolation, danger, and confinement for a relatively long period of time; and

b) it promises the rewards associated with productive work of intrinsic value to the crew members.

The behavior of small groups of men in such an environment is of great interest to both NASA and the Department of Defense. A good deal of information has been obtained by NASA and DOD on crews operating in ground-based simulation environments performing artificial tasks in artificial environments. However, direct knowledge of the behavior of small groups operating in "natural" isolation and confinement with real stresses and real rewards is almost completely lacking. The information that does exist is based upon studies which are by their very nature grossly different from the present study in many important respects.

Consider, for example, studies of Antarctic wintering over parties. A number of excellent studies have been conducted on such groups and much valuable information is available. However, all these studies suffer from the inability of the investigators to conduct on-the-spot investigations. Data from submarine crews is similarly largely dependent on long range techniques of study. Studies of other natural groups, such as the Mt. Everest climbing team, have been conducted by participant observers. The problem in such research is the possible contaminating effects of observer bias. The most similar studies to the one being contemplated on this crew are the research on SEALAB II aquanauts

and the projected studies of SEALAB III crews. The information and techniques from the present study will benefit greatly from conceptual and methodological developments in the SEALAB II research. The presently proposed research should in turn contribute a great deal toward improving future research of a similar nature.

Information from this study can be expected to have a bearing on questions of crew selection, training, group composition, group organization, and group maintenance functions. In addition, improved methodology of measuring behavior in natural environments can be expected. Finally, it is not too much to expect that information on this group, and the potential conceptual and methodological implications, will greatly assist in understanding normal working groups as well as those in exotic environments.

Three characteristics of this project make it very attractive for naturalistic research:

A. The Duration of Exposure to the Environment

It is probably safe to say that no group has been studied as intensively as this group can be studied for such a long period of time in an environment such as the one available in Tektite. By the environment is meant the combination of the conceptual characteristics of the stresses involved and the intrinsic rewards of the work. The hazards and stressors include:

Physical hazards of Tektite:

| | |
|---|---|
| Toxic flora | Saturation diving constraints (sudden, accidental surfacing produces injury and possibly death) |
| Predatory fauna | Closed ecological system |
| Toxic fauna | Heavy reliance on mechanical equipment for survival |
| Artificial respiratory atmospheres | |

Situational stresses of Tektite:

| | |
|---|---|
| Isolation | Forced social interaction |
| Confinement | Extensive personal time and ego commitment, close scrutiny of performance |

| | |
|---|---|
| Monotony | Lack of privacy |
| Celibacy | High intra-group responsibility |
| Restricted relaxation outlets | Reliance on surface support for survival functions |

B. The Accessibility to the Capsule

It is virtually certain that clear and continuous video and audio access to the entire capsule (with the exception of agreed upon "privacy" areas) can be afforded by closed circuit television and microphones. Because of the relatively normal respirable atmosphere, and the possibility of controlling ambient noise, it should be possible to monitor conversations in the capsule quite well.

C. The Favorable Attitude of the Crew and the project sponsors toward their being investigated in the manner proposed here.

## MEASUREMENT REQUIREMENTS AND METHODS

The behavioral measurement program will be directed at determining:

1. the direction and extent of behavioral deviations from established pre-mission baselines;

2. the absolute values of behavior/performance function, where appropriate;

3. the causal relationships between manifest behavior and such factors as personality structures, demographic data, elapsed time, environmental stressors, normal operational procedures, and perhaps the occurrence of unanticipated phenomena;

4. the usefulness of the various methods of measuring human behavior and performance which will be carried out.

Because the number of men in the primary sample is so very small (four), statistically significant correlations between performance during the mission and demographic and personality variables will not be possible, However, it is important that these demographic and personality variables be measured, so that the Tektite data can be combined with data from other operations, past and future, to derive valid correlations of this type.

Correlations which can be significant within this study are those between different aspects of behavior and between behavior and aspects of the environment which occur either simultaneously or at earlier points in time. For example, it can be expected that variations in such a performance measure as diving time will be correlated with variations in measures of social interaction and emotional adjustment. A simple, illustrative hypothesis might be that the "better" a man's social relations with his fellow divers, the greater will be his amount of diving time or the more stable it will be across the entire mission. It should be apparent that the actual relationships will be complex and that any conclusions will be tentative. It will be possible, however, to develop specific hypotheses which may be verified and extended in other similar situations. A major goal of this program is to provide results and to develop and strengthen theoretical concepts which can be used in organizing a variety of data from field, laboratory and simulation studies.

In keeping with this goal, the program will also have significant methodological implications. First, it will be possible to develop, test and standardize methods of acquiring necessary data for use in studying similar situations. Second, an attempt will be made to determine the minimal quantity and types of data which are necessary to get reliable and valid measures of given conceptual variables. Since several estimates of each conceptual variable will be available, it is possible to determine if measures not requiring such close and continuous access to the environment as that available in this situation will produce reliable and valid results.

SUBJECTS

The prime subjects of behavioral investigation will of course be the four scientist-divers who comprise the crew of the Tektite habitat. They are: 2 marine biologists from the Bureau of Commercial Fisheries; 1 marine biologist from the Bureau of Sports Fisheries; and 1 marine geologist. However, limited data will also be collected on: 2 marine biologists who serve as back-up crew and on-shore scientific monitors; 12 behavioral monitors; and selected members of the on-shore operational crew.

The rationale for collecting behavioral data on these topside personnel is:

1. Since these individuals will resemble the habitat crew in background, personality, and professional

interests, and since the sequence of events that they experience will be similar in many ways to that experienced by the habitat crew, they will serve as useful and illuminating controls on a number of the objective measures.

2. The behavior of topside personnel is significant in itself. For example, the tasks confronting them contain elements and responsibilities of the jobs which will have to be performed by flight controllers on long duration space missions. Indeed, the stresses accompanying these responsibilities may well be more intense in some instances that those stresses confronting the habitat crew.

SELECTION

Due to the highly specialized nature of the primary scientific goals of this program, the habitat crew for Tektite has already been selected, subject to review by the involved agencies, from the scientific staff of the Department of Interior. Hence, the application of ordinary procedures for crew selection will be somewhat ex post facto. However, these individuals, who are highly trained marine scientists and qualified divers, will go through a battery of medical and psychological tests (see Table II: Summary of Pre-Mission Measures). Any significant negative results on this battery, or during the training procedures, will lead to revision of the crew. Descriptive data should be obtained on operational personnel who interface extensively with the crew during the Tektite mission for possible correlation with performance data and for comparison with future operations of a similar nature.

TRAINING

During the training process outlined below, normative data on various operational tasks (e.g., maintenance and repair of the environmental control system) will be obtained for comparison with parallel measures during the missions. For further details on such comparisons, see Table IV: Performance Assessment from Routine Tasks.

I. Diving

The dive is at the saturation depth of 50 feet. The men have been selected in part because they are experienced divers. Therefore, there is no need for additional training with diving equipment or procedures.

II. Habitat Familiarization

A. Dry Land Training

1. General Electric Facilities

a. Subsystem and System Familiarization and Operations

b. Maintenance and Repair Procedures

c. Operational Ingress and Egress Procedures

d. Emergency Ingress and Egress Procedures

e. Medical Monitoring Procedures - Atmosphere - EKG - EEG

f. Integrated Station Operations

2. Other Dry Location

a. Experiment Equipment and Procedures Familiarization

3. On Site

a. Shore Station Operation - Briefing

1. Life Support
2. Electrical Power
3. Communications
4. DDC, Emergency Operation, etc.

B. Wet Training

1. On Site - Pre-Installation

Area Familiarization and Explanation

2. On Site - Part Installation

a. Subsystem and System C/O

b. Maintenance and Repair Procedures

c. Station Operations

d. Operational Ingress and Egress Operations

e. Emergency Ingress and Egress Operation

f. Experiment Operations

g. Medical Monitoring Operation

h. Mission Aborts

III. Physiological - Biomedical Procedures

During the habitat familiarization training of the aquanauts time will be allocated sufficient to bring each aquanaut to proficiency in the techniques of obtaining blood samples, urine samples, EEG, and pulmonary data, etc.

IV. Decompression Tests

To insure the safety of the oxygen-nitrogen breathing mixture, decompression from a hyperbaric $N_2$-$O_2$ mixture, 50 ft. saturation level will be conducted in a pressure chamber in New London. This procedure will result in the establishment of safe decompression schedules. During this 10-day test, other safety tests will be conducted, and some baseline behavioral data may be obtained, since the regular and back-up crew will participate.

CONCEPTUAL CATEGORIES FOR BEHAVIORAL MEASURES

I. Task Performance - Individual and Group

A. Routine Operational Tasks (see Table IV).

B. Diving and Scientific Activities (see Table V).

Under this category are included measurements directed at assessing the ability of the crewmen, singly and in concert, to carry out motor, sensory, and intellectual tasks required of them in the mission plan.

II. Social Interaction (see Table VI)

Included in this category are measures aimed at identifying, describing, and quantifying those interactions between individual crew members, and between the crew and topside personnel, which tend to support or degrade the successful accomplishment of mission objectives, crew morale, and crew and system survival.

III. Personal Adjustment (see Table VII)

In this category are measures of the individual crew member's emotional and motivational status, trends and cycles in that status, particularly as such factors relate to accomplishment of program objectives.

IV. Habitability (see Table X)

Measures in this area are aimed at determining the impact of physical and functional characteristics of the internal and external habitat on: (a) performance effectiveness; (b) physical and emotional well-being; and (c) social interaction.

V. Human Engineering of Diving Apparatus/Science Support

Measures in this category are similar to those in the Habitability area, but are directed at evaluating the suitability of particular items of underwater equipment and at determining guidelines for optimizing human scientific activity in an isolated and hostile environment with limited technical resources.

OPERATIONAL CATEGORIES FOR BEHAVIORAL MEASURES

1. Direct observation by audio and TV monitoring system, and by visual examination from surface during dives.

2. Instrumented measures of specific behaviors.

3. "Paper-and-pencil" record: personal and scientific diaries, sortie reports, mission records.

4. Direct, real-time crew reports and comments.

5. Physiological measures of psychological significance (see Tables VIII and IX).

PROCEDURAL COMMENTS

The principal method of data collection will be video and audio observation. This observational data will be handled by two parallel approaches, with separate personnel for each approach.

In the first approach, which is in the tradition of behaviorism and ethological field observation of animals, data collection will concentrate on objective recording of observed behavior. The observations will be made by behavioral monitors (probably local college students) who will be trained on the job. These monitors will make relatively few interpretations of behavior. As in the "double-blind" techniques routinely used to minimize observer bias in drug evaluation studies, the monitors will not be familiar with the hypotheses of the principal investigators. Their task will be to record

what occurred in a standardized recording format. For the most part, information will be recorded on previously prepared forms with an emphasis on measures of time and frequency. Each data bit will be given a unique man, time, signature. Where appropriate, measures will be coded by exact location as well. Any ratings performed will also be carried out in standardized procedures, with emphasis on specific events rather than global evaluations. The bulk of behavioral interpretation will be done during reduction and analysis of the raw data. Standardization will be aided by a requirement that the data be reduced to a form suitable for computer analysis.

The second approach, which is in the tradition of clinical psychology, will utilize interpretive observation by skilled (Ph.D. or M.D. level) professional personnel. These personnel will be responsible for conferring with the on-site physician should questions arise about the safety of continuing the mission. They will also be responsible for preparing narrative accounts of unusual and significant events. These accounts will be backed up by audio or video tape recordings. Data collected by the two approaches will be correlated after the mission, and all data will be made available to all involved organizations.

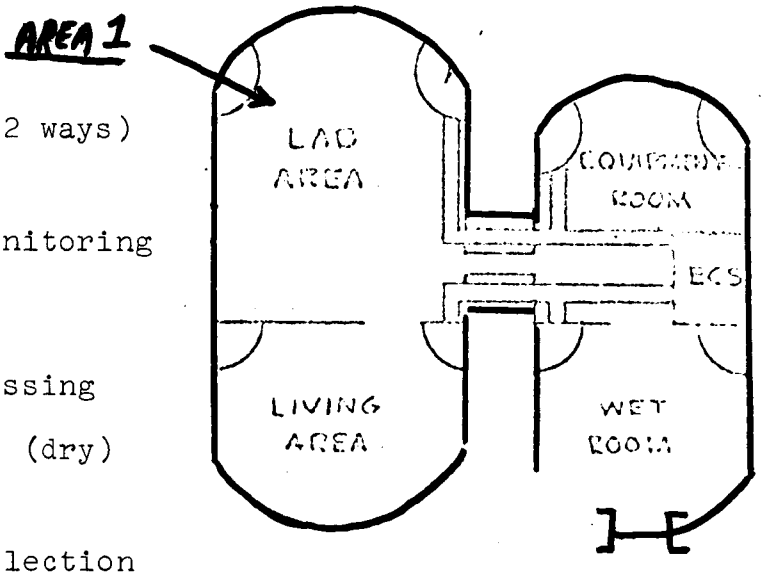
Most of the observational measures to be gathered will not be pure measures of any of the conceptual variables. This is because the measures are so complex and interrelated that it is not possible to classify any broad category of behavior under any single conceptual group. Specific activities, however, can and will be so classified. One such classification is presented in Tables II-X below. The measures listed therein are comprehensive, but not all-inclusive. On the other hand, some of the measures listed may prove impractical to actually carry out. However, sufficient amounts of data will be no problem on this project. The problem will be in selecting the best indicators of the various conceptual criteria. The methodological standards against which the measures will be evaluated are summarized in Table I.

Many of the measures listed are also "impure" in the sense that they contain component variance that is determined by exigencies of schedule, water conditions, etc. However, these measures also contain a substantial segment of genuine human performance variance. By taking a number of such measures, it is possible during analysis of the data to converge upon an index of performance that would go untapped if only "pure" behavior measures were taken.

# APPENDIX

## HABITAT LAYOUT AND ACTIVITIES IN VARIOUS AREAS

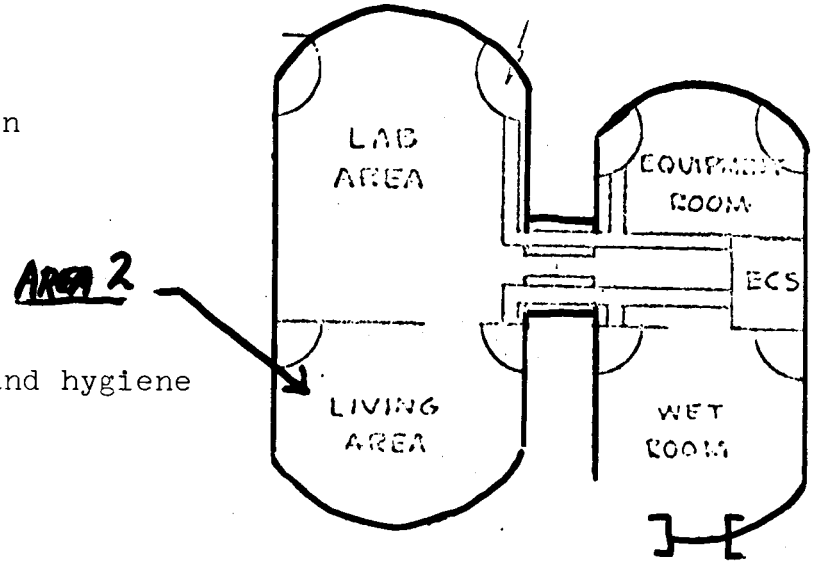
Area 1




- Operations control
- Survey communications (2 ways)
- Maintenance
  - all ECS and safety monitoring equipment
- Station keeping
- Experimental data processing
- Experimental operations (dry)
- Visual observation
  - Experimental Data collection
  - Crew safety
- Biomedical/Behavioral operations
- Instrumental calibration, repair, replacement of expendables
- Relaxation
- Semiprivate retreat
- Moderate wet detailed specimen processing

Area 2

- Sleep
- Relaxation/recreation
- Food preparation
- Eating
- Social interaction
- Personal cleansing and hygiene
- Toileting
- Reading/writing
- Visual observation
  - Experimental data collection
  - Crew safety
  - Recreation
- Emergency egress/ingress
- Private retreat
- Food/equipment storage and retrieval



Area 3

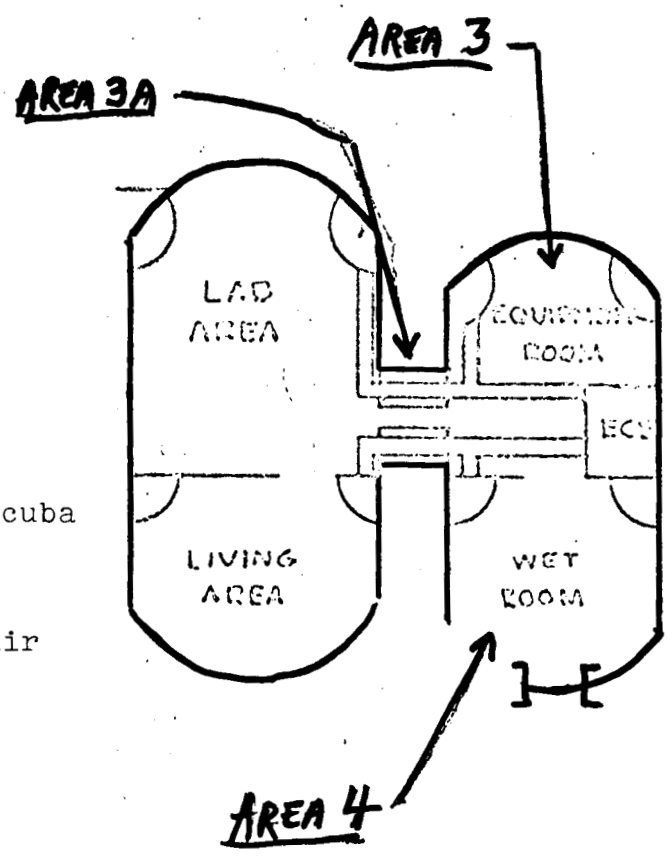
. Check out and monitor
. Maintain
. Storage/retrieval

Area 3a

. Traverse
. Transport of material (inter-compartment)

Area 4

. Doff/don scuba
. Maintenance and refilling of scuba
. Pre- and post-dive equipment preparation area
. Equipment maintenance and repair
. Wet analysis
  . dissection
  . physical measurements
  . drawing
  . photography
  . microscopy
  . preliminary specimen processing
. Showering
. Standard ingress/egress
. Sortie report (duration and preliminary description)
. Storage/retrieval
. Logistic preparation area
. Biomedical/behavioral operations
. Emergency first aid
. Visual observation
  . experimental data collection
  . crew safety



Area 5 Natural Extra-Habitat Ecology

- Monitor/observe local ecology (physical organic, transient phenomena, direct eyeball, t.v., photographic. etc.)
- Collect physical specimens
- Survey physical geography
- Collect geology specimens
- Hunt and collect
  - live flora and fauna
  - inorganics
  - coral
  - shells
  - sand
  - stones
  - sediment
  - water, etc. (live specimens will be trapped, stunned, or killed)
- Communicate with habitat, surface, and diving buddy
- Travel (swim with scuba or hookah)
  - swimming
  - bottom walking
  - one man powered sled
  - small multimanned submersible
- Conduct locational and quantitative census of locality regarding all animate and inanimate objects of interest

Area 6 Experiment Modified Extra-Habitat Ecology

. Carry out maintenance on exterior of habitat

. Activate and deploy instrumentation and experimental equipment

. Collect data from physical equipment (readouts or specimens) traverse across experimental area

. Modify physical ecology or animate contents for experimental operations

. Cooperate with surface work teams as indicated

. Implement logistic procedures

. Store and retrieve externally located expendables

. Accomplish emergency rescue/retrieval

. Check out and maintain emergency way stations/equipment/ decompression facilities

. Possible biomedical behavioral procedures

## TABLE I

## CRITERIA FOR EVALUATING PHYSIOLOGICAL AND BEHAVIORAL MEASURES

(Methodological Experience)

A. Reliability
   1. Internal consistency of measure.
   2. Stability of measure on repeated application when no significant changes have occurred in environment or well-being of aquanaut.

B. Validity → Measure correlates with other measures of known validity and/or with significant events.

C. Predictive Capacity → When and if "critical incident" occurs, which measures "foresaw" it previous to occurrence.

D. Simplicity → In underlying assumptions, in carrying out, in analysis: most simple measure which does the job is best.

E. Non-interference → The less interference with mission operations, the better.

F. Uniqueness → Does the measure have genuine variance which is not predicted by other measures?

## TABLE II

## SUMMARY OF PRE-MISSION MEASURES

1) Demographic Data

Age
Education and employment record
Diving and other related experience
Marital and parental status
Family size and density index
Birth order
Family mobility
Size of home town
Anti-social behavior record
Religious affiliation

2) Results of Complete Physical and Dental Examination

Including, but not limited to:

Tests of pulmonary and respiratory function*
Tests of cardiovascular function (including Harvard Standard Step Test and EKG)
Complete blood analysis+
Complete urine analysis#
NASA EEG Data Bank Tests

3) Personality Data

Edwards' Personal Preference Schedule
Allport-Vernon-Lindzey Scale of Values
Selective Word Memory Test
Underachiever Index
Pensacola Z Scale
Impulsivity Scale
Ratings by clinicians

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* Vital capacity, timed vital capacity, maximum ventilatory volume, transpulmonary pressures, diffusion constant for carbon monoxide, residual volume, airway resistance, lung compliance, etc.

\+ Hemoglobin concentration, red cell size and count, differential and total white cell count, reticulocytes, platelet count, Lee-White coagulation, etc.

\# Specific gravity, calcium, nitrogen, catecholamines, 17-OHCS, etc.

TABLE II (Continued)

4) Social and Adjustment Data

Sociometric Questionnaires
Mood Adjective Check List Baseline
Sleep Baseline

5) Training Data

Performance Assessment on Routine Tasks During Training
Time-Motion Analysis of Selected Tasks
Pre-Mission Habitability Walk-Through Forms

TABLE III

SUMMARY OF POST-MISSION MEASURES

Results of Complete Physical and Dental Examination

Debriefing Interview

Sociometric Questionnaires

Habitability Questionnaire

Science-Support and Diving Equipment Evaluation Forms

Post-Mission Sleep Monitoring

Self-Satisfaction Rating

Number and Rated Quality of Scientific Reports Derived From Mission

TABLE IV

PERFORMANCE ASSESSMENT FROM ROUTINE TASKS

| Operation | Behavioral Measure | Sensing/Recording Technique |
|---|---|---|
| Monitoring Environment Parameters and Life Support System | Adherence to watch schedule | D.O.+, protocol checklist |
| | Frequency of monitoring each indicator | Written records |
| | Accuracy of monitoring | In-habitat recorded value vs. surface indicator value* |
| | Time to notice ECS abnormality | D.O., timers |
| | Time to correct abnormality (if controllable from habitat) | D.O., timers |
| Mission-Related Communication to Surface | Number of "false alarms"<br>Number of failures to communicate necessary information to surface | D.O., Analysis of transcripts, mission records |
| Preventative Maintenance | Frequency of performance of each task by each crewman | D.O., checklist |
| | Time to perform | D.O., timers |
| | Adequacy of maintenance | D.O., rating form |
| Malfunction Repair Tasks | Frequency of performance by each crewman | D.O. |
| | Time to perform | D.O., timers |
| | Number of "errors"<br>a. Wrong part isolated<br>b. Damage done in process of repair | D.O., evaluation form |
| | Adherence to routine | D.O., protocol checklist |
| Housekeeping Tasks (e.g., meal preparation, cleaning up, storage, etc.) | Frequency of performance of each task by each crewman | D.O. |
| | Adequacy of performance | D.O., rating form |

+Direct Observation by TV or audio

*Monitoring: For a number of environmental parameters, there will be both read-out dials in the habitat and direct lines to topside indicators. For example, at one location in the habitat, there will be both a sound-level meter (portable) and an open, calibrated microphone. Continuous automatic recordings of many of the surface indicators (with appropriate time scale) will be made. These recordings will permit accuracy checks and also measurement of reaction time of both habitat and surface crew to abnormalities. Other indicators, which are not so instrumented, will require coordinated observations between habitat and surface if accuracy checks are to be made.

Normative Data for comparison with above measures will be obtained as follows:

A. For simple, repetitive functions, behavior can be compared with same act performed by same crewman at previous times in mission (time course).

B. Some tasks can be compared to learning curves and envelopes of assymptotic performance during training .

C. Some tasks (e.g., time to notice ECS abnormality) can be compared to performance of same by topside monitors at same time during mission. Such comparisons must, of course, be tempered by consideration of differences in displays, watch schedules, etc.

D. For performance measurement on complex, unanticipated abnormalities in ECS, comparison data may be generated by simulating malfunction on control panels for safety drill purposes. The crew will be informed that unannounced drills will be conducted.

NASA-MM will take upon itself the task of coordinating the above data (at least during the analysis stages) with on-going studies of performance assessment from Gemini and Apollo operational telemetry. Making the Tektite results compatible with classification and analysis schemes that have been developed in the Gemini-Apollo studies should be beneficial to both endeavors.

TABLE V

PERFORMANCE ASSESSMENT FROM DIVING

AND SCIENTIFIC ACTIVITIES

| Operation | Behavioral Measure | Sensing/Recording Technique |
|---|---|---|
| Preparation for Dive | Adequacy of preparation | D.O., protocol checklist |
| | Time spent preparing | D.O., timers |
| Diving | Number of dives per day | D.O., sortie reports |
| | Length of each dive | In-habitat timer, sortie reports |
| | Number of observations per dive | Sortie reports |
| | Number of specimens collected per dive | Sortie reports |
| Post-dive activity | Adequacy of securing | D.O., protocol checklist |
| | Time spent securing | D.O., Timers |
| | Expressed satisfaction with dive | D.O., scaling form for verbal expressions |
| Scientific Activity | Global Measures<br>Accomplishment/Aspirations Ratio<br>A. Over whole mission<br>B. Periodically (e.g., weekly) | D.O., scientific logs., checklists of original plans and periodic, revised plans |
| | Self-Satisfaction with scientific performance | Paper-and-pencil self-rating.<br>Verbal expressions of same. |
| | Rating of performance by topside scientists | Rating form, anchored to data samples, specific scientific hypotheses, etc. |
| Data collection, Processing | Number of specimens collected per day | Sortie reports, scientific logs, direct measurement of samples brought up in physical recovery system |
| | Amount of data per day | |
| | Amount of data per "opportunity" | |
| | Quality of data processing (e.g., slides prepared) | Rating by topside scientists |

TABLE V (Continued)

| Operation | Behavioral Measure | Sensing/Recording Technique |
|---|---|---|
| | Accuracy of data recorded, transmitted (Sequential course as mission progresses, each scientist compared with himself.) | Comparison with surface measurement of samples. "Parity" and other checks of data transmission. |
| Preventative Maintenance and Repair of Scientific Equipment | Frequency of performance | D.O., checklist |
| | Time to perform | D.O., timers |
| | Adequacy of maintenance | D.O., rating form |
| | Number of "errors"<br>a. Wrong part isolated<br>b. Damage done in process of repair | D.O., evaluation form |
| Occurrence of Unexpected Phenomena | Yes/No record of whether opportunity was successfully exploited<br>Qualitative description of event | D.O., Sortie reports, scientific logs. |

TABLE VI

ASSESSMENT OF SOCIAL INTERACTION

| Variable Class | Behavioral Measure | Sensing/Recording Technique |
|---|---|---|
| Gregariousness | Time spent by each man in company of others | D.O., timers |
| | Frequency of initiating social contact | D.O., interaction analysis form |
| Territoriality | Time spent by each man in various areas of habitat | D.O., timers |
| | Occurrence, frequency of verbal "defense" of an area | D.O., interaction analysis form |
| | Preference for specific bunks, working areas, etc. | Post-mission rating by crew |
| Group cohesiveness, clique formation | Who eats with whom | D.O. |
| | Who dives with whom | D.O. |
| | Frequency, temporal distribution of size of groups working together | D.O. |
| | Psychological distance and sociometric questionnaires | Paper-and-pencil, pre- and post-mission. |
| | Number of personal communications to surface (for all crew members combined) | |
| | Also, communication process measures below | |
| Within-Habitat Interaction Process | Samples of verbal and other overt social behavior will be recorded and analyzed by a social interaction analysis scheme. Emphasis will be on whole-group activities such as meals. | D.O., interaction analysis form, tape recording |
| Habitat-Surface Interaction Process | Interaction analysis similar to above | D.O., interaction analysis form, tape recording. |

TABLE VI (Continued)

| Variable Class | Behavioral Measure | Sensing/Recording Technique |
|---|---|---|
| | Frequency of "complaints" | |
| | Frequency of disregard of or resistance to surface requests, mission rules and protocol | |
| Leadership function, "pecking order" | Order of entering and leaving water on dives | D.O. |
| | Who assists whom with diving gear, etc. | D.O. |
| | Frequency of initiating group activity for each crew member | D.O., interaction analysis form |
| | Identity of group spokesman for communications to surface control | D.O. |

TABLE VII

ASSESSMENT OF PERSONAL ADJUSTMENT

| Variable Class | Behavioral Measure | Sensing/Recording Technique |
|---|---|---|
| Activity Level | Number of moves from chamber to chamber of habitat per unit time | D.O. |
| | Number of times in and out of range of single camera per unit time | |
| Goal Orientation | Time up in morning | D.O. |
| A. Maintenance of Mission Discipline | Observers rating of personal cleanliness | D.O., rating form |
| | Occurrence of mission rule breaking (Frequency, importance) | D.O., exception reporting form |
| | Occurrence of "accidents" (Frequency, seriousness) | D.O., accident report form |
| B. Escape/Avoidance Behaviors | Number of personal communications to surface | Communications record Mail record |
| | Evasion of monitoring: | |
| | Amount of time per day "off camera" | From analysis of D.O. records |
| | Occurrence of behaviors which obstruct monitoring (Initiator, frequency) | D.O. |
| | Amount of time per day spent in non-mission activities (e.g., recreation, napping, etc.) | Cumulated from D.O. |
| Mood | Mood Adjective Check List--periodic short form | Paper-and-pencil form (alternate versions for methodological purposes) |
| | Mood content of daily social interactions → from analysis of within-habitat and habitat-surface interactions | D.O., interaction analysis form |
| | Observer rating of mood (on awakening, at meals, etc.) | D.O., rating form |

TABLE VII (Continued)

| Variable Class | Behavioral Measure | Sensing/Recording Technique |
|---|---|---|
| Motivational Profile | Breakdown of daily activity into drive categories. E.g.: Amount of time in food related activities; Amount of time spent in various bodily functions (washing, grooming, toilet functions, etc.); Frequency of sex-related activities (e.g., sexual jokes); Amount of time in personal vs. group-interest tasks | D.O., scoring system for drive categories |
| | Nature of recreational activity engaged in | D.O., projective analysis of recreation |
| Need for and Adequacy of Sleep | Number of times up during night | D.O. |
| | Number and length of daytime naps | D.O., timers |
| | Psychophysiological monitoring of sleep (see Table IX) | |
| Appetite | Number of meals and snacks per day | D.O. |
| | Amount eaten at each meal | D.O., recording form |
| | Rating of satisfaction with food | D.O., standard 9-point scale of food acceptability (Wright-Patterson) |
| Manifest Anxiety | Occurrence of specified anxiety behaviors | D.O., checklist |
| | Qualitative description of such behavior and its antecedents | Event description form |
| Overt Aggression | Occurrence of specified aggressive behaviors | D.O., checklist |
| | Qualitative description of such behavior and its antecedents | Event description form |
| Symptoms | Occurrence of specified symptoms (tics, headaches, etc.) | D.O., checklist |
| | Self-report of specified symptoms | Paper-and-pencil |
| | Queries as to specified symptoms in periodic medical interview by topside M.D. | Direct report |

## TABLE VIII

## ASSESSMENT OF PHYSIOLOGICAL STATUS

(The following measures do not properly fall in the Behavior Program, and final responsibility for their definition and execution rests with the Tektite biomedical team. However, in the analysis of specific parameters of human behavior, it is essential that all factors potentially capable of causing deviations from baseline performance be identified and controlled. The measures below will aid in doing this, and they are included to emphasize the "whole man," psychophysiological approach that should be utilized in Tektite.)

| Variable Class, Procedure | Physiological Measures | Apparatus |
|---|---|---|
| Respiratory and Pulmonary Function (Routine performed once per week) | Vital capacity<br>Timed vital capacity<br>Inspiratory<br>Expiratory<br>Maximum Ventilatory Volume | Spirometer, Kymograph |
| | Transpulmonary pressures | Swallowed balloon |
| Cardiovascular Function (Routine performed once per week, coordinated with respiratory tests) | Heart rate, EKG changes caused by above ventilatory maneuvers | EKG electrodes, inhabitat recorder or channel to surface |
| | Harvard Step Test Equivalent<br>Rate of change due to initiation and maintenance of specific work load<br>Absolute levels of heart rate obtained<br>Elapsed time to develop maximum rate<br>Rate of change during post exercise period<br>Elapsed time to return to pre-test rate | NASA can supply bicycle ergometer |
| | EKG waveform before, during and after exercise. | |

TABLE VIII (Continued)

| Variable Class, Procedure | Physiological Measures | Apparatus |
|---|---|---|
| Hematological functions (small sample of blood collected once per week, analyzed in habitat, slides sent to surface) | Hemoglobin concentration<br>Red cell size and count<br>Differential and total white cell count<br>Reticulocytes<br>Platelet count<br>Lee-White coagulation | Microscope, sampling syringe, slides, chemicals |
| Metabolic, endocrine functions | Urine analysis<br>Specific gravity<br>Calcium<br>Nitrogen<br>Catecholamine levels<br>17-OHCS levels | Samples collected periodically, frozen and sent to surface for analysis |
| | Body weight (daily) | Scale |
| | Body temperature (before and after selected dives) | Ear insert thermometer |
| Weekly eye, ear, nose, and throat exam (aquanauts check each other) | Examine for specified symptoms | Ophthalmoscope, tongue depressors, symptom checklist |
| Weekly medical interview | Performed weekly by topside M.D., coordinated with above measures | |

TABLE IX

PSYCHOPHYSIOLOGICAL MONITORING OF SLEEP

I. DESIRABLE PHYSIOLOGICAL PARAMETERS

| Parameter | Justification | Procedural Comments |
|---|---|---|
| Electroencephalogram (EEG) | For definition of sleep stages; index of neurological functioning | Highly desirable, but difficult to instrument. Low signal level, electrodes bothersome. |
| Electrooculogram (EOG) | To differentiate rapid-eye-movement (REM) "dreaming" from Stage I sleep. | High signal level, but electrodes may be bothersome |
| Electrocardiogram (EKG) and Heart Rate (HR) | For evaluation of cardiovascular function; good indicator of metabolic effects of daytime activity | Easy to instrument with minimal interference. Aerospace experience useful for both: Electrode placement. Analysis techniques. |
| Respiratory Rate and Depth (Impedance measure) | For evaluation of pulmonary function; for correlation with EKG and HR → reflex function | Can be obtained from EKG electrode with proper circuitry |
| Skin Potential (SP) fluctuations | Sensitive indicator of daytime stress | Easy to instrument with minimal interference |
| Body temperature | For elucidation of metabolic effects | Optional; earplug or rectal sensor |
| Body movement | Sleep disturbance indicator; also clarifies changes in other parameters | Easily instrumented, either through sensor in bed or artifacts in other parameters |

TABLE IX (Continued)

II. BASIC SLEEP MEASURES OF PSYCHOLOGICAL SIGNIFICANCE

| Psychological Concept | Sleep Measure |
|---|---|
| Adequacy, depth of sleep | Amount of sleep stages (I, II, III, IV, REM) per night in comparison with baseline nights<br>Number of transitions from stage to stage (inversely related) |
| Stress from prior day's activities | Amount of Stage IV sleep per night (inversely related)<br>Number of SP fluctuations per night (especially during Stage IV)<br>Heart rate during early-evening sleep |
| Stressful anticipation, Subjective uncertainty | Amount of theta activity per night<br>Amount of REM sleep per night (?) |

III. PROCEDURAL AND EQUIPMENT REQUIREMENTS

1) Techniques for application of electrodes and recording of data must cause minimal interference with pre-sleep activities and sleep itself. Certain parameters (for example, EEG) may have to be discarded if the equipment for their measurement cannot be suitably simplified. It is better to have a Spartan measuring package which will work throughout the mission than an elaborate set-up that is rejected by the aquanauts or malfunctions after a few nights.

2) Some sort of sleep record for each aquanaut on every night of the mission is highly desirable. Alternate night monitoring of difficult parameters (EEG, EMG) may be acceptable, however.

3) Baseline sleep measures should be obtained prior to the mission over several nights, including nights following real-life stresses for clarification of individual sleep patterns. In addition, the crew should be run through the NASA EEG Normative Library procedures at the Methodist Hospital in Houston.

4) Sleep measures, both baseline and during-mission, should be correlated with the Mood Adjective Check List and daytime environmental and behavioral events.

5) A quick-look capacity should be incorporated in recording equipment so that sleep data can be included in day-by-day evaluations of mission safety.

6) Physiological monitoring of sleep should be considered for some on-shore personnel as a control.

TABLE X

ASSESSMENT OF HABITABILITY

I. Pre-Mission Evaluation

Review of habitat designs and mock-ups
→ Application of Navy Standards (OPNAV 9330.5A)
→ Application of NASA Standards (Habitability Checklist -MM)
→ Crew walk-through with comment forms
- Note Nominal Values versus Observed Values
- Correct major discrepancies
- Note minor discrepancies, uncertainties for particular attention during mission.

II. During-Mission Evaluations .

1. Environmental Monitoring (contaminants, noise, etc.)
2. Direct observation of crew in habitat
- Circulation patterns (paths of movement, frequency, length)
- Utilization patterns (amount of time spent in various areas, unused spaces, etc.)
- Daily power consumption and peak levels
- Daily water consumption and peak levels
- Daily oxygen consumption and peak levels
- Daily production and peak levels of carbon monoxide and other contaminants
- Record on TV tape: crew-produced alterations in habitat (moving of furniture, etc.)
- Record accidents, inconveniences due to habitat configuration
- Choice of recreational activities, trends in same
- Food choices, amounts eaten
- Clothing utilized: Type, amount of wear in material
- Duty-rest schedules: Change as mission progresses
3. Crew Comment
- Periodic habitability questionnaires
- Relevant comments in logs
- Verbal comments during operation
- TV-tape record of specific design inadequacies

III. Post-Mission Evaluation

1. Extended habitability questionnaire for crew.
2. Analysis of observational data
3. Coordination with pre-mission reviews: Are standards supported or do they require revision?

BELLCOMM, INC.

Subject: The Tektite Project Behavior Program. Case 710.

Date: April 11, 1968

From: N. Zill

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